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PLANTING CONSIDERATIONS AND EROSION-CONTROL FABRICS

Successful restoration of native riparian plant cover on streambanks and floodplains requires an understanding of fluvial processes, such as sediment deposition, hydraulic scour, inundation and drought associated with falling water tables. These processes are distinct to riparian zones, and riparian vegetation is well adapted to these processes. Because the dynamics of the riparian zone require that vegetation be highly specialized to survive, planting strategies and plant materials developed for traditional landscaping or reforestation projects may not be well suited to the streambank environment.

This appendix provides a framework for revegetation planning and implementation based on riparian and fluvial processes and provides instruction on the use and installation of erosion-control fabrics to stabilize the planting area.

PLANTING CONSIDERATIONS

The list of steps shown below is the recommended sequence for most riparian revegetation plans. Each step in the sequence is discussed in more detail in this appendix.

1. Conduct a site review;
2. Identify site constraints;
3. Develop design criteria;
4. Select plant-material types (e.g., woody, herbaceous, bare-root, seed, potted);
5. Select plant species;
6. Determine planting density and layout;
7. Schedule timing of plantings;
8. Consider site-preparation requirements;
9. Determine planting techniques; and
10. Define procedures to monitor and maintain project

Site Review

A vegetation site review consists of collecting specific vegetation-related data at a project site for use in development of a revegetation plan. A site review should include the specific project reach and a functional reference site, preferably in the same or a nearby watershed with similar site conditions. Use the reference site as a tool to aid in the design of a planting plan for the project area. At a minimum, the information below should be collected:

- *Plant Distribution/Colonization* – note the distribution of dominant woody and herbaceous species (including weeds) relative to river stage, hydrology and shade, and which plants are colonizing freshly deposited soils. Look for and identify any good sources for local cutting collection and/or plant salvage.
- *Shade* – observe and note how canopy cover will affect light availability for new plants.

- *Lower Limit of Perennial Vegetation* – determine the lowest bank elevation that will support perennial vegetation. This is most accurately determined on gradually sloping banks, where an easily observed continuum exists, ranging from unvegetated channel to annual plants to perennial plants. If possible, how this elevation relates to river discharge should be noted.
- *Depth to Groundwater* – ideally, this is determined using test pits or monitoring wells; but, in the absence of such tools, it is often estimated using the elevation of late-summer base flow.
- *Soils* – describe existing soils on different bank and channel features such as bars and overbank-deposition areas. Note the soil texture (e.g., sandy, rocky, clayey, organic). Note whether soils are well-drained (gravelly or sandy) or poorly drained (clayey or organic), droughty or wet, friable or highly compacted by livestock or heavy-equipment operation. Look for cut banks that identify soil profile by depth. Are shallow soils or till present? Additional information that can be helpful but is not often collected includes soil pH, salinity and nutrient status. This information can be obtained by sending a sample to a soil lab or by testing it with a home soil test kit.
- *Human/Wildlife Use of the Site* – note whether there is existing or a potential for human and animal foot traffic, recreational river use, grazing, deer and elk browsing, beaver activity, or other potential impacts to vegetation and soil.
- *Hydrology* – check to see if portions of the site periodically flood. If so, attempt to determine how often and for how long. Look for physical indicators of high flow, such as sediment deposition, woody debris and trash.
- *Geographic Characteristics* – determine the elevation, slope and aspect of the site. Plant species harvested for revegetation projects that come from high elevations on the slope may not grow well at low elevations. Some species are more adapted to steep slope conditions and provide greater resistance to slope erosion than others. South-facing slopes are much drier than north-facing slopes.

Site Constraints

Early in the revegetation-planning process, it is important to identify potential factors that may limit successful revegetation. While site constraints for plantings are often biological or physical site factors, less obvious constraints are related to project budget and management or to the scheduling of construction activities. Often, recognition of site constraints early in the planning process can lead to a creative solution that not only may increase plant survival but also simplify construction and possibly save money.

Below are some possible site constraints, many of which are specifically related to natural riparian processes.

- weed competition;
- heavy shade;
- over-compacted soils;
- overly drained soils;
- poorly drained soil;
- deep summer water table;
- shallow soils/bedrock;
- high amounts of sediment deposition;
- large flood events expected soon after planting;
- potential ice flows/ damage;

- poor native-species availability;
- soil compaction due to heavy foot traffic (human or animal);
- nearby seed source of noxious weeds
- construction-sequencing conflicts;
- livestock, deer and elk grazing/trampling/browsing;
- heavy beaver damage;
- incompatible mowing and pruning activities (a common problem at golf courses and near power lines);
- rodent problems;
- extended inundation;
- high soil salinity (a common problem in arid areas th
- dam-influenced hydrology;
- tide-influenced hydrology;
- limited site access;
- insufficient maintenance budget;

Design Criteria

While not necessary for all projects, it is recommended that revegetation planning begin with development of design criteria. Design criteria are specific guidelines that quantify desired performance attributes to meet objectives. A general revegetation guideline or objective might be “to provide habitat” or “to provide erosion control,” whereas a design criterion might be “to provide overhanging shrub cover along 50 percent of bank within three years.” Design criteria for vegetation should specify requirements for habitat needs, size of material, species diversity and erosion control.

Plant-Material Types

Plant-material type refers to the form in which the plants will be when obtained and planted into a particular project site. Examples of plant-material types include cuttings, seed, containerized, bare-root stock, and ball and burlap stock. They are further classified into herbaceous and woody plant categories. Base the selection of specific woody or herbaceous plant-material types on design objectives or design criteria, site conditions, and site constraints. Most projects tend to use a combination of woody and herbaceous plant-material types.

Woody Plant Material

Woody plants, which include both shrubs and trees, are widely used in riparian restoration projects to provide bank stability, habitat and aesthetic appeal. Their roots tend to be strong and deep, mechanically reinforcing soils by adding tensile strength.[1] Large riparian trees contribute large, woody material to streams, and all woody plants provide good shade and cover to streams. On many streams, undercut tree and shrub roots provide excellent fish habitat, especially the roots of mature cedar, hemlock, and spruce. Multiple, flexible shrub stems dissipate stream energy and encourage sediment deposition rather than scour. Below, common, woody types of plant material are briefly discussed.

<u>Cuttings</u>. Cuttings consist of harvested stems of dormant shrubs and trees. They are capable of developing both roots and shoots if planted in proper conditions. For the best chance of success, cuttings should be harvested during the dormant season, preferably fall

or spring,[2] and planted within days of collection. By far, the most commonly used and successful cuttings are those taken from a variety of willow (*Salix* spp.). Other species commonly used in Washington with good success include red-osier dogwood (*Cornus stolonifera*) and black cottonwood (*Populus balsamifera trichocarpa*). Species that are less commonly used but root well from cuttings include salmonberry (*Rubus spectabilis*), elderberry (*Sambucus* spp.), Pacific ninebark (*Physocarpus capitatus*), mallow ninebark (*Physocarpus malvaceous*), black twinberry (*Lonicera involucrata*), Nootka rose (*Rosa nutkana*), and spirea (*Spiraea* spp.).[3,4]

Keep in mind that not all of the species listed above are appropriate in live-stake applications due to their relatively small, flexible branches, but they are appropriate as components of fascines and brush layers. Few other riparian shrubs or trees native to Washington reliably and consistently root from cuttings. Cuttings are popular in bank-stabilization projects because they are inexpensive and can be collected in long lengths capable of accessing deep (10- to 12-foot) water tables. Whether installed as live stakes, fascines, or brush mattresses, cuttings provide excellent erosion control and bank stabilization. More detail on cuttings is provided later in this appendix under *Planting Techniques*.

<u>Containerized</u>. Containerized plants refer to nursery-grown plants established from seed or cuttings and planted in any one of dozens of different sizes and shapes of containers. They are distinguished from most other types of plant materials on the basis of their well-developed soil/root mass, allowing planting to occur throughout much of the year, provided adequate water is available. If installed plants are irrigated, they can be installed in the dry summer months, which is an advantage when construction occurs during summer low-flow months. Another distinct advantage of containerized plants, especially in contrast to cuttings, is that many riparian woody (and herbaceous) plant species native to Washington State can be obtained in this form. Conifers such as cedar, spruce and hemlock are usually acquired as containerized plant material.

Although conventional landscaping nurseries typically provide containerized plants in one-, two-, or five-gallon containers, some native-plant nurseries make use of a much wider array of containers that are better suited to streamside conditions. For example, a deep but narrow container known as a tubeling or plug has dimensions of approximately one inch wide by six inches deep. The greater depth-to-width ratio of the tube provides the plant with better resistance to pullout caused by flowing water and better access to deep, moist soil than conventional nursery containers. Other innovative containers include, but are certainly not limited to 14-inch-deep treepots®, PVC pipe four to six inches wide by one to two feet long, biodegradable burlap "socks" and biodegradable coir (coconut-husk fiber) containers.

<u>Bare-root</u>. Bare-root plant material is a type of nursery-grown, woody plant-material widely used in riparian restoration. Woody plants in the bare-root form consist of rooted plants sold with the soil removed and packaged with damp sphagnum moss or sawdust

and sold in bundles. Bare-root plant material generally requires smaller planting holes than comparatively sized containerized plants because you don't have to make room in the hole for soil packed around the roots. Although often much less expensive (one-tenth the cost of container stock), bare-root plants can be less forgiving and more delicate during the planting stage and may not survive if stored or planted incorrectly. Bare-root plants are becoming increasingly available, both in number and species diversity, at native-plant-material centers, nurseries and local conservation districts. Locally collected material is harder to find, but some nurseries can accommodate special requests with advance notice. The main limitation of bare-root plants is their narrow planting window (late winter/early spring dormant season). Bare-root plantings may be successful even when planted later into the spring if well watered through the summer.

Ball and Burlap. The mainstay of the landscaping industry, ball-and-burlap plants consist of mature trees and shrubs ranging from six to 12 feet tall. Plants are shipped from nurseries with their roots "balled-up" and wrapped in burlap and wire. Their large size makes ball-and-burlap plants less susceptible to animal grazing and weed competition, and it adds an element of structural diversity to a revegetated area. However, ball-and-burlap plants are considerably more expensive than other forms of plant material and their large size and relative bulk make handling difficult, requiring guy wires and staking for stability during the first one to two years after planting.

Salvaged. Another type of woody plant material consists of salvaged or transplanted plants. Ideally obtained on-site, salvaged shrubs and trees are those that otherwise would be destroyed or disposed of during the construction phase of a stream restoration project or another nearby construction project, but are instead salvaged and replanted to add biological, economic and aesthetic value. If carefully coordinated, excavators or tree spades can cost effectively transplant a large number of seedlings, saplings and, sometimes, mature shrubs and trees. In addition to great cost savings (provided equipment and transportation costs are low), salvaged plantings can provide immediate benefits to bank stability, structural diversity, cover and aesthetics compared to smaller forms of plant materials. Their large root mass may also make them resistant to flood flows.

When salvaging plant material, keep in mind that salvaged plants are an assemblage of living stems, root crown, and roots excavated as a contiguous unit. In addition, the soil bound by the roots is considered a component of the salvaged plant.[6] Consequently, successful salvage requires excavation of a sufficient portion of the soil root mass to support the above-ground foliage. On small plants all of the root mass may easily be obtained with the use of a shovel or backhoe. On larger shrubs or trees large excavators and tree spades are required, and some trees may have root masses too extensive to allow for salvage and transplant. To reduce the shock of transplanting, dormant plant materials are preferred, but if flood or winter conditions require non-dormant salvage, irrigation may be needed to maintain soil moisture until late fall [6].

Pruning woody stems and branches may help reduce drought stress. According to the Thurston County Master Gardener Foundation,[5] native plants that are easily salvaged include:

Vine maple (*Acer circinatum*),
Bigleaf maple (*Acer macrophyllum*).
Red alder (*Alnus rubra*),
Beaked hazelnut (*Corylus cornuta*),
Oregon ash (*Fraxinus latifolia*),
Indian plum (*Oemleria cerasiformis*),
Pacific ninebark (*Physocarpus capitatus*),
Douglas fir (*Pseudotsuga menziesii*),
Cascara (*Rhamnus purshiana*),
Nootka rose (*Rosa nutkana*),
Clustered rose (*Rosa pisocarpa*),
Red elderberry (*Sambucus racemosa*),
Snowberry (*Symphoricarpos albus*),
Western red cedar (*Thuja plicata*), and

Seed. On some sites, there may be interest in experimenting with western red cedar using direct seeding, as discussed in the Soil Rehabilitation Guidebook.[6] Otherwise, seeding of woody species is not a recommend means of establishing vegetation at a stream restoration site.

Herbaceous Plant Material

Herbaceous plants consist of grass and grass-like plants including rushes, sedges, ferns, and forbs (wildflowers). They are characterized by fine-textured roots that grow between six and 24 inches deep, depending upon plant species, soil type and site hydrology. In contrast to woody plants, most herbaceous plants tend to form dense cover over the soil surface, although some species tend to be more clumped. Their fine mats of roots and dense cover combine to provide excellent soil reinforcement and protection from surface soil erosion. Unlike some woody species, the flexible stems of herbaceous plants bend or flatten under flood flows, providing high-flood conveyance.

Seed. Seed is the most common type of herbaceous plant material because it is relatively inexpensive; and, if planted properly, it can quickly establish itself as a short- or long-lasting ground cover. In reconstructed streambanks, seed is generally installed by hand or with a mechanical seeding device, and it is covered with a temporary erosion-control fabric to protect the seed from wash-out during flood events. Seed is also available in pre-seeded erosion-control mats. This product may be beneficial on steep slopes where it would otherwise be difficult to place seed. However, pre-seeded mats are relatively expensive, and their use often results in spotty vegetative cover. Seed can also be applied using hydroseeding methods; however, hydroseeding is not recommended for streambanks because it offers little protection against flowing water. Some suggestions for selecting the most suitable mix of seed are discussed later in this appendix under *Planting Techniques*.

Containerized. Nursery-grown herbaceous species are widely available in containers that are similar to those described under the previous discussion on *Woody Plant-Material Types*.

Bare-root. Emergent, wetland, herbaceous plants such as bulrush (*Scirpus spp*.) are available in bean-sized, bare-root fragments. Easy to install and far less expensive than containerized plants, streambank plantings of bare-root herbaceous plants are appropriate if covered with erosion-control fabrics to prevent flood flow wash-out. Like woody bare-root stock, herbaceous bare-root stock must be planted in their dormant season (late winter to early spring) and may require supplemental irrigation.

Salvaged. Salvaged sod, if available, is an outstanding type of herbaceous plant material. It has a dense soil/root mass that is relatively resistant to erosive forces; it establishes quickly; it's cost effective, and it makes use of materials that would otherwise be discarded. Salvaging and transplanting sod requires an excavator or other specialized, heavy equipment.

Prevegetated Mat. Similar to salvaged sod in terms of its advantages, another interesting type of herbaceous plant material is a pre-vegetated coconut mat that resembles conventional turf sod. The mats are characterized by dense root systems that quickly penetrate into the soil once installed. The coconut mat provides temporary erosion control until the vegetation gets established. Available from some Washington native plant nurseries, these products can be a low-risk (but expensive) means to quickly establish herbaceous cover.

Plant-Species Selection

All streambank and floodplain revegetation projects should use, and are often required to use, native plants naturally occurring in the project area. Unlike introduced species, native plants are genetically adapted to the local climate, compete well for survival on native streambank soils, and are resistant to local insect infestations. Choosing native plants grown with seed or cuttings collected from sites in similar, local watersheds will preserve the genetic integrity of the local stock and will have the highest likelihood of success. There are over 40 native-plant nurseries in the state of Washington.[7]

Species for each chosen plant-material type (e.g., herbaceous seed or woody cuttings) should be selected with an emphasis on the following:

- suitability for anticipated climate, hydrology, elevation, soils and site constraints of planting site;
- reasonable availability in desired quantity (either from nurseries or a local source);
- probability of successful establishment (based on best available experience or information);
- desired growth form or shape and size (as specified in design criteria); and
- ability to achieve desired plant diversity (as specified in design criteria).

Planting a variety of species ensures the highest likelihood of project success. Monocultures are susceptible to total failure when exposed to disease or unfavorable site conditions. Consider planting a mix of fast- and slow-growing plants, deciduous and evergreen. Remember to use information gathered in project- and reference-site characterization during species selection. Table H-6 provides a list of native species one might consider using on stream restoration projects. This list is not exhaustive, but it does provide helpful information to consider during the plant selection process. Consult plant guides or native-plant nurseries for further information on specific plants. As with any purchase, when choosing a source of plant material, assess the quality of the plants; cheaper is not necessarily better.

Special Considerations

Exposure Tolerance of Plants During Establishment. When choosing plants for a disturbed streambank or floodplain, consider each plant's role in plant succession. Pioneer tree and shrub species such as red alder (*Alnus rubra*), black cottonwood (*Populus trichocarpa*), willow (*Salix* spp.) and salmonberry (*Rubus spectabilis*) are naturally tolerant of extreme, adverse conditions, such as low soil-nutrient status, moisture stress (with the exception of salmonberry), and full sun and wind exposure. Alternatively, some desirable conifers, such as western red cedar (*Thuja plicata*) and western hemlock (*Tsuga heterophylla*), form late-succession forests and establish best under shady, relatively protected conditions.[3] Planting such seedlings in direct-sun locations often fails. Success may be substantially improved if seedling planting is delayed until a nearby shrub and/or tree layer develops a canopy, offering at least partial shade.

Plant Density and Layout

Plant densities for restored streambanks and floodplains are often determined on a "plant per linear foot" basis, if planting on a narrow strip along the water's edge, or on a "feet on center" basis if planted on larger or wider areas. Table H-1 provides general guidelines concerning recommended densities for different types of plant materials. Remember that these recommendations are only a starting point for planning and may need to be increased or decreased depending upon such factors as project budget, erosion-control requirements, probability of survival, and anticipated time to maturity.

Table 1. Recommended Densities for Plant Materials

Plant Material Type	**Planting Density (highly site dependent)**
Cuttings	1-2 ft on-center or planted in bundles (fascines) or dense rows of brush mattresses and willow rows (Shiechtl and Stern, 1994))
10-cubic-inch herbaceous plantings	2 ft on-center (10,890 plants per acre)
10-cubic-inch containerized shrub	3 ft on-center (4,840 plants per acre)
10 cubic inch containerized tree	10 ft on-center (435 plants per acre)
1-gallon rooted willow container	5 ft on-center (1,742 plants per acre)

5-gallon cottonwood container	10 ft on-center (435 plants per acre)
1.5-inch-diameter stem, ball & burlap tree	20 ft on-center (109 plants per acre)
Seed mix	Seeding rate depends upon species

Note that a small increase in planting density can increase the number of plants per acre substantially. For example, decreasing plant spacing from five feet on-center to three feet on-center increases plants per acre from approximately 1,792 to 4,840. Table 2 provides planting-density conversions.

Table 2. Planting density equivalencies.

ft on center	sq. ft per plant	plants per acre
1	1.0	43,560
2	4.0	10,890
3	9.0	4,840
4	16.0	2,722
5	25.0	1,742
10	100.0	435
15	225.0	193
20	400.0	109
25	625.0	70

After densities for plants are determined, the layout or distribution of plants across a site must be decided. The simplest approach is to distribute plants uniformly across appropriate hydrologic planting zones, evenly distributing different species at a specified spacing. Such an approach is most likely to result in uniform coverage and allows for easy installation and monitoring (especially several years later after vegetation gets thicker). This approach may not, however, optimize fish and wildlife habitat and aesthetics. Instead of focusing on even distribution, an alternative planting approach is to base the planting layout on the size and type of material, the individual plant species habits, and the habitat needs of fish and wildlife. For example, low-growing shrubs and/or herbaceous plantings might be distributed uniformly across a certain zone such as a streambank, while tall shrubs are clustered near pools to provide fish cover. When planting a number of varieties in the same area, it is often best to group similar plants together in clusters rather than interspersing all species equally. This mimics many natural plant distributions, which tend to be more aesthetically pleasing. Plants that tend to form thickets, such as salmonberry (Rubus spectabilis), may be planted close together. Plants that tend to grow as solitary individuals, such as many tree species, may be planted further apart.

When planting the floodplain or riparian zone above the top of the bank, future maintenance requirements should also be considered. Grasses and weeds surrounding new plants often need to be mown or otherwise suppressed for three years or more to minimize competition until the plant is firmly established. New plants often need supplemental water during the first year (and sometimes through the second summer) following planting. Maintenance will likely be easier if plants are grown in distinct clusters or bands because the plants themselves will be easier to find, and the area requiring the use of hand-held tools to suppress weeds can be narrowed to within and immediately outside of the cluster or band. Weed suppressors that operate on a larger scale, such as mowers, can be used between plant clusters, if necessary. Heavy mulch between plants within the cluster or band will suppress weeds and conserve moisture so as to minimize the necessary frequency of maintenance. However, mulch is not generally recommended in areas subject to frequent flooding. Maintenance issues are of a lesser concern when planting the streambank itself because the desired outcome there is generally uniform coverage, which will likely happen if the newly planted vegetation is simply left alone.

Timing of Plantings

Each plant material type has a specific planting window of survival, based on its biological needs as summarized in Table 3. It should be noted that, in riparian areas, timing of flood flows or wet site conditions might prevent or limit site access during otherwise acceptable planting periods.

Table 3. Recommended Planting Window

Plant-Material Type	**Recommended Planting Period**
Seeding	Spring/fall is best; summer seeding needs irrigation
Dormant cuttings	Spring/fall is best; possibly winter or early summer
Containerized/rooted plantings	Spring/fall is best; summer plantings need irrigation
Bare-root plantings	Late winter/early spring only
Salvaged trees/shrubs	All year, but dormant season (November to March) is best; irrigate and prune summer transplants
Salvaged sod	All year; irrigate summer/fall transplants
Ball and burlap trees	Spring/fall is best

Site Preparation

Because of the natural fluvial processes that occur in streambank planting areas, some site-preparation strategies used in upland forests, grasslands and landscaped areas are of questionable value. For example, techniques used to control competing vegetation in uplands, such as weed mats and mulch, may not be appropriate on streambanks subject to frequent flooding because they collect debris or are washed away during flood flows. In addition, along a streambank, deep-rooted shrubs and adjacent shallow-rooted grasses may not compete against each other as they do in upland plantings. Streambank grasses grow in the spring when surface moisture is available; but woody plants, once established, draw their water from deeper in the ground, rendering them better able to survive periods when surface soils are dry. During the establishment period, however, weed and grass suppression surrounding newly planted native plants may be critical to plant survival, especially when planted in heavily vegetated areas such as pastures and meadows, or in areas dominated by aggressive, noxious weeds, such as reed canary grass and blackberries.

Soil fertilizer that is regularly applied in uplands may not be appropriate in streambank zones for several reasons. First, many riparian species naturally thrive in relatively sterile soil, characterized by high sand and gravel/cobble content and may already be adapted to low-nutrient sites or obtain their nutrients in association with stream flow. Second, surface applications of fertilizer may be washed away by flood flows and add excess nutrients to the aquatic system before plants can absorb them. Third, weeds may be more competitive on fertilized sites than on typical alluvial sites that are dominated by low-nutrient, sandy and gravelly soils.

If soil amendments or supplements such as compost, topsoil or fertilizer are to be used, they should be organic products with slow-release characteristics, and they should not be applied to the surface of the soil. Rather, they should be mixed into the rooting zone with existing soils. Amending existing soils and physically incorporating these amendments into the rooting zone increases their retention under flood flows and may encourage deeper rooting than if amendments are simply placed on the soil surface.

An amendment that may be worth considering in droughty sites, at least on an experimental basis is “water crystals.” Water crystals are synthetic polymers added to the rooting zone that can improve moisture retention and thereby allow plants to better withstand drought.

Note that additional site preparations, including fencing and weed control, may be required to address any identified site constraints.

Planting Techniques

Proper treatment of plant material, including storage and planting techniques, is critical to the success of a stream restoration project that incorporates vegetation. All plants used on site should have a healthy, vigorous appearance, free of dead wood and disease. Care should be taken to properly store plants prior to planting, protecting them from sun, wind and physical abuse. The appropriate planting technique in streambank settings depends on the type of plant material, as shown in Table 4. If planting is to be done in an area that’s heavily vegetated, such as a pasture or meadow, remove vegetation from at least a three-inch-diameter circle where the new plant will be set to minimize competition. All plants should be watered immediately after planting to eliminate air pockets and to ensure that moisture around the root ball is at or near field capacity. More details on planting techniques are provided later in this section.

Plant Material Type	**Planting Techniques**
Seeds	Hand broadcast or mechanically seed under erosion-control fabric. Lightly compact seeded soil. No till direct seeders can be used when planting large, flat floodplain areas
Dormant cuttings	Depends upon application; see details below.
Container/rooted plantings	Hand tools or use mechanized planting tools.
Bare-root plantings	Hand toolssuch as planting bar.
Salvaged trees/shrubs	Transplant with backhoe, excavator, tree spade or by hand.
Salvaged sod	Transplant with excavator or specialized equipment.
Ball and burlap trees	Plant with crew and backhoe or by hand; stake with guy wires.

Table 4. Planting Techniques.

Developing Seed Mixes. Seed mixes are a combination of grass and grass-like plant species intended to provide both short- and/or long-term cover, depending upon the specific project. Some suggestions follow:

- More species are not necessarily better. Select three to five species with a range of seed sizes that are biologically suited to your site.
- Do not specify hard-to-find or unavailable species.
- To the extent possible, use locally collected seed.
- Select seed containing a low percentage of weeds.
- Select at least one proven, quick-establishing species. This may justify use of short-lived non-native cover crops, such as annual ryeor winter wheat. Or try a sterile hybrid such as regreen or a native, dry-site species, such as slender wheat grass or Canada wildrye, that provides good short-term erosion protection but will eventually be replaced by a species more tolerant of moist soils. Short-lived species are particularly appropriate when vegetation established by seed is expected to provide only short-term erosion control until native herbaceous and woody plants get established. Short-lived species will provide less long-term competition.
- More seed is not necessarily better. Instead, focus on getting good seed-to-soil contact by firmly compacting seeded streambank areas with excavator tracks, an excavator bucket or a contractor's compacter. Imprints left in the soil by tracked equipment during construction can help to collect seed and rainwater and provide a moist microclimate for seed germination.
- Have a seed supplier help determine seed rate, and purchase seed in pounds of Pure Live Seed (also referred to as "PLS lbs.").
- Experiment with different species, and monitor results.

- After applying a simple seed mix containing three to five species, add diversity by separately seeding a wildflower mix in scattered locations across the seeded area.
- To maximize survival, seed should be planted during the correct planting season as recommended by the seed supplier. To provide erosion control during the winter months, seed must sprout and root well prior to the start of the winter dormant season. Straw mulch can increase the likelihood and rate of seed germination, even if the straw later washes downstream. Erosion-control fabrics can be used in conjunction with or in place of straw mulch to prevent straw and seed from washing downstream.
- Where the potential for natural recruitment of native vegetation is high, lightly seeding the area may be more effective than heavily seeding. This will limit competition for the native vegetation.

Collection, Harvest and Installation of Cuttings. Live cuttings are the most common type of plant material used on streambanks. This appendix lists many on-line and published planting guidelines. Some additional tips related to collection, storage and installation are described below:

- Best survival occurs with dormant collection and plantings, but anecdotal reports suggest that successful establishment is sometimes possible from cuttings planted in early summer and early fall, especially if leaves and branches are stripped from the plants and cuttings reach the water table or are irrigated.
- Collect cuttings from healthy vigorous stock. Collect cuttings from male and female plants, if applicable. One- or two-year-old wood is generally better than older wood, and cuttings taken from the center and bottom of the plant will frequently root better than those taken from the outside edges. A general rule of thumb is to take no more than 1/20 of an individual plant.[4] When harvesting cuttings, don't clearcut the source area.
- Cuttings should be at least one half inch in diameter, 12 to 18 inches long, and include two or more nodes (buds). One (or more) nodes is for the roots of the new plant and one (or more) is for the leaves. Some plants have very long sections between nodes so your cuttings may need to be longer the 18 inches. Longer cuttings may also be necessary depending upon planting site conditions (e.g., deep water table) and application (e.g., brush layers and fascines versus live stakes). Experiment with a variety of cutting diameters, since literature on the most successful stem diameter is not consistent and varies depending upon species under consideration.[4] Cutting diameters less than one half inch may be necessary for some species (e.g., *Symphoricarpos* spp. and *Spirea* spp.).
- When harvesting cuttings, mark the base of each cutting with a clean, diagonal cut, and make sure the base of each cutting is inserted into the ground. Upside-down cuttings rarely survive.
- Cuttings should be kept moist, relatively cool, and shaded until planting. Even on a cold day, exposure to direct sunlight will stress them. The literature suggests that soaking cuttings (at least that portion of the cutting that will be underground) in water for 24 hours or more prior to planting improves survival. This is also an excellent, temporary, on-site storage method. Water should be changed daily. Cuttings will be most successful if harvested and planted in the same day.

- If cuttings cannot be installed within days of collection, consider long-term storage (up to several months) under cool, damp, dark conditions (refrigeration).
- Never plant cuttings into dry soils.
- If the site is not irrigated, the bottom of the cutting must reach a depth where the soil is permanently damp. The literature is not conclusive on what percentage of the cutting should extend above ground. One quarter is often recommended (especially for arid areas), no more than one half, but experiment with variations and monitor results. When planted, at least one node should be buried and one node left exposed to establish roots and shoots, respectively.
- Ensure good stem-to-soil contact by installing in compacted soils. The stake must fit tightly in the planting hole, leaving no air space.

Be creative with planting techniques; refer to the discussion in Chapter 5, *Techniques* that addresses Riparian Restoration and Management for more discussion on specialized planting techniques.

- Consider planting dense willow “rows” (3-5 per lineal ft) in an excavator-made trench, rather than “hand” planting individual cuttings. Cuttings should be 5-10 ft in height; trench should be at least half the length of the cuttings; and trench should reach water table. Such willow rows are inexpensive, do not require irrigation, resist pullout during flood events, and create floodplain roughness.

<u>Installing Containerized Plant Materials</u>. The success of planting techniques for containerized plants depends in large part upon the specific container size and dimension, making generalizations difficult. For example, narrow “tubeling” containers can be planted through erosion-control fabric with minimal fabric cutting, but larger containers require cutting fabric strands that can potentially weaken the fabric. On particularly erosive sites, the advantages of larger material should be weighed against the potential for compromising fabric strength and integrity. Depending upon the situation, planting holes can be hand dug with shovels and dibble bars, or with a variety of mechanical equipment including augers, excavators and backhoes. The planting hole should be roughly twice the diameter of the container. Loosen and uncoil circling or twisted roots. All container plants need to have the top of the soil/root mass planted flush with or slightly higher than the soil surface, and have a suitable backfill material firmly compacted around the root mass. A trough or low soil berm around the planting hole may be used to retain water. However, care should be taken to keep the trunk base dry. Irrigation is recommended in many cases, but is generally not required for dormant-season plantings. If using mulch, avoid letting the mulch come in contact with the stem.

<u>Planting Bare-Root Materials</u>. For best success, bare-root plants must be planted during the later winter/early spring dormant season. If irrigation is available, the planting season may extend into late spring and possibly early summer, but survival may be low. Roots should be fresh and plump, not dry and withered. Store bare-root plants in a cool, shaded environment with roots covered by moist (but not soggy) mulch or sawdust. Roots must be kept moist and protected from sun and wind exposure at all times. Greater success may result from soaking the root system in a bucket of water over night prior to planting. Installation requires attention to detail, including digging a broad and deep enough

planting hole to accommodate roots without cramping, making a firm cone of soil in the hole, spreading the roots over the cone, positioning the plant at the same depth or slightly higher than it was grown in the nursery and backfilling firmly with a good growing medium. A planting bar can also be used. A planting bar will create a slit in the soil that the roots are placed into, the slit is then closed using the planting bar. Roots must be cut to the length of the planting bar to prevent bending the roots at the bottom of the slit. If circumstances dictate, create a trough or low soil berm around the planting hole to encourage retention of water. However, care should be taken to keep the trunk base dry. Irrigation is recommended during the first, and sometimes second, growing season following planting, but may not be needed if seasonal, natural precipitation or moist soil conditions are anticipated. If using mulch, avoid letting the mulch come in contact with the stem. As in the case of large, containerized plants, bare-root trees and shrubs planted through erosion-control fabric require that the fabric strands be cut, thereby weakening the fabric. For this reason, on particularly erosive sites, the advantages of bare-root stock over cuttings should be weighed against the potential for compromising fabric strength and integrity.

<u>Planting Salvaged Materials.</u> Heavy equipment such as a backhoe, excavator or tree spade is advised. While storage and/or transport of salvaged materials is possible, the increased handling, especially for woody materials, tends to increase cost and reduce survival rates. Salvage is best implemented when the following sequence can be followed:

1. prepare the planting site (including excavating i holes if needed);
2. salvage plants, by excavatingas much of the root mass as possible and directly transferring the salvaged plant to the planting site with as the soil and root mass intact; and
3. Install the salvaged plants in moist soil immediately.

Minimizing transport of salvaged materials is key to their success and survival. Make sure the roots stay damp; they will dry out in seconds if exposed. If the plants must be stored before replanting, they should be handledas ball-and-burlap plants. Transfer the plant from the ground with the dirt around its roots still intact onto a strip of burlap placed alongside the plant. Tie the burlap around the root ball with twine, keeping the dirt intact. To properly store the newly created ball-and-burlap plants, cover the root mass with moist mulch or sawdust. Following planting, irrigation is always advised, and pruning of woody stems and branches will help reduce drought stress.[4, 6]

Dormant-season salvage is best (November through March)although this is often not possible on the eastside due to frozen ground, but if irrigation is available and the risk of somewhat lower survival is acceptable, salvage can take place even in dry or hot seasons. Salvaging plants is most successful if plants are collected and planted on wet, cloudy days so that roots are less likely to dry out.

<u>Installing Ball-and-Burlap Plants</u>. Nurseries that supply these types of trees and shrubs can provide excellent planting guidelines. Remember, the large size of the planting hole

and the potential for guy wires to collect flood debris limit the application of this plant material type on streambanks. These problems may be less of a concern on floodplains.

Maintaining the Restoration Site

Where establishment of native vegetation is critical to the long-term stability of the bank, planting is just the beginning. A commitment needs to be made to maintain the site until the plants get established, generally considered three years. Young trees and shrubs are very susceptible to drought, competition with other vegetation for moisture, light, and nutrition, and browsing/trampling by livestock and wildlife. During the first three years following planting, inspect the area every few months (perhaps more during the dry season) to identify problems and implement repairs/modify management strategies, as needed.

If planting was done in a pasture or otherwise heavily vegetated site, vegetation surrounding the plant should be periodically removed or mown down to maintain the original three-foot-diameter open area surrounding each plant. Mowing twice a year during the first three growing seasons is generally recommended – once in the spring and once in midsummer. On sites where reed canary grass grows, a third mowing in the fall right down to the ground is sometimes recommended to reduce the amount of grass that comes back up the following spring. Consult your local or state noxious weed control board for more information concerning noxious-weed control and removal.

Livestock fences should be inspected and maintained to prevent livestock access to the planted area. Even small numbers of livestock or short-duration grazing can severely reduce plant survival. Although non-palatable species may not be impacted by grazing, they are subject to other impacts such as trampling.[7] Temporary or permanent fences may also be needed in areas subject to heavy foot and pet traffic such as at parks.

Aluminum foil, arbor guards or photodegradable, plastic-tube, plant protectors may be needed to protect plants from being girdled by rodents, a common problem in pastures and meadows. Plastic-tube plant protectors offer the additional benefits of shielding plants from direct sun and wind exposure; they retain moisture, creating a humid microclimate, and they protect plants from mowers. Other types of barriers or repellents may be needed to protect plants from deer, elk and beaver during the plants' critical period of establishment. Planting species capable of stump sprouting or suckering from roots (identified in Table 6 by a "†") will reduce long-term grazing impacts.

Drought is a particular hazard to young plants due to their smaller tissue mass and less-developed root system. Plants that are not planted deeply enough to reach the zone of saturation will need to be watered regularly throughout the dry season until the fall rains. The need for watering will vary depending upon site conditions and the depth to which vegetation was planted. Watering heavily and infrequently, as opposed to frequent shallow watering, encourages deep root growth, which increases drought tolerance. In general, plants should be watered for at least the first growing season, and watering should only be stopped when the plants develop root systems capable of reaching a depth where the soils are permanently moist. This normally occurs by the end of the second growing season.[7]

EROSION-CONTROL FABRICS

This section of the appendix reviews erosion-control fabrics (also called rolled erosion-control products), including discussions on fabric types, selection considerations, costs and installation considerations. This section is applicable to stream restoration techniques discussed in Chapter 5, *Techniques*, Riparian Restoration and Management technique

When to Use Erosion-Control Fabric

Erosion-control fabric should be used on stream restoration projects under the following conditions:

- where loose soils on a restored bank can be eroded during anticipated high flows;
- when shear stresses on banks at flows less than or equal to the design flow are between approximately 0.5 psf and 5.0 psf;
- where initially stable, but ultimately deformable bank-treatment techniques have been selected;
- when plant materials, such as seed and tubelings, need protection from the force of flowing water; or
- when performance thresholds of the selected fabric are not exceeded during design flows. (If thresholds are exceeded, other means of protection may be required.)

Fabric Types

For the purposes of this discussion, erosion-control fabrics are grouped into one of two broad categories, degradable or nondegradable. Degradable fabrics provide erosion protection for approximately one to five years and include biodegradable products made from natural fibers, and photodegradable synthetic products. Nondegradable fabrics are typically made from synthetic materials and are resistant to decay for at least 10 years after installation.

Degradable Fabrics

In an order of increasing strength or resiliency, degradable fabric types include straw, jute, coir and a few types of synthetic fabrics. Straw and jute are excellent for uplands but are generally not resilient enough for streambanks and floodplains. Thus coir and, to a lesser extent, photodegradable synthetics fabrics are the most applicable for streambank restoration purposes.

Coir fabric is a relatively inexpensive fabric ($1.00 to $3.50 per square yard) made of coconut-husk fibers. It is available in either a blanket-like, nonwoven fabric or a stronger, longer-lasting woven type. *Nonwoven coir fabric* consists of fiber strands sandwiched between two thin layers of cotton, jute or photodegradable netting, and lasts between one and two years in most climates, although the photodegradable netting has been observed to last up to five years.[8] *Woven coir fabric* is commonly used in streambank restoration because it is available in wide and long rolls (16' x 165' or 4m x 50m); it's strong, and it provides erosion protection for two to four years, depending upon site conditions. The biggest drawback of woven fabric is the open area between woven strands, which may allow loss of fine-textured soil particles. Where such loss may be detrimental to a project's success, woven fabric is often used as an outer layer over a nonwoven or finely woven inner fabric. A few suppliers have recently made available a degradable product that integrates both an inner, nonwoven layer and a stronger, woven layer. Such a fabric combines the best characteristics of both and is still relatively cost-effective ($2.50 to $3.50 per square yard).

Factors that directly affect the decay of degradable fabrics include ultraviolet radiation, microbial decay and physical abrasion. Even at a single site, the degree to which any one of these factors contributes to fabric decay varies substantially. Factors that may increase fabric longevity include constant inundation, dense vegetative cover and, in arid locations, burial under fine sediments. Fabric degradation rates may be increased by frequent wetting and drying, humid climates, scour from a mobile bedload or physical abrasion from foot traffic. Degradation rates of woven coir fabric are discussed in more detail a conference paper called "Degradation Rates of Woven Coir Fabric Under Field Conditions," authored by D. E. Miller, T. R. Hoitsma and D. J. White .[8]

A fundamental concept related to the use of degradable fabrics is that the fabric will provide initial, surface erosion protection; but, by the time fabric decays (one to five years, depending upon the product), vegetation will be sufficiently established to stabilize streambank soils. This relationship between fabric decay and plant establishment underscores the importance of selecting an appropriate fabric and the necessity of an aggressive revegetation plan.

Nondegradable Fabrics

Nondegradable fabrics, by nature of their synthetic materials, are often considered less desirable along natural streambanks than degradable fabrics. In addition, nondegradable fabrics can be more expensive and harder to work with than degradable fabrics. Yet, they are a cost-effective substitute for "hard" bank-protection measures such as riprap, and they are generally very compatible with plantings. Common types include:

- two-dimensional biaxial grid ($2 to $3 /yd^2): strong and inexpensive, but requires the use of inner fabric to prevent loss of fines through the fabric openings. The Natural Resources Conservation Service uses this material in its soil reinforcement system.[9]
- two-dimensional blankets: comprised of synthetic fibers bound between synthetic netting ($3 to $5 /yd^2). Not widely used on streambanks.
- Three-dimensional, multilayered woven fabric ($7 to $8 /yd^2): a high-performance fabric with a pyramid-like matrix. Expense limits its use.
- Composite fabric with three-dimensional, synthetic-fabric matrix integrated with nonwoven coir ($3 to $5 /yd^2): a relatively cost-effective, high-performance fabric that works well on streambanks.

Selection of Fabric Types

The first choice in fabric selection is between degradable and nondegradable types. Usually this is based on design criteria for deformable vs. nondeformable protection and fabric performance relative to a range of bank shear stresses at a site (see Table 5). Guidelines and sources that can help determine the appropriate fabric are listed below:

- As a very general and conservative guideline, shear stresses greater than one to two psf require nondegradable synthetic fabrics.
- Manufacturers provide performance data for their products. However, consider that some fabric-securing methods may have a lower erosion resistance than the fabric itself. Also, information provided by different suppliers may be reported in different units or result from different types of tests. Generally, manufacturer-reported performance data is liberal and not necessarily legitimate in application.
- Although not a direct indicator of field performance, comparisons of manufacturer-provided "wet" or "dry" tensile strength (commonly reported as test ASTM-4595) is a good measure of absolute fabric strength at the time of installation. Tensile strength of degradable fabrics deteriorates rapidly under many site conditions.
- The Texas Department of Transportation has a website, www.dot.state.tx.us/insdtdot/orgchart/cmd/erosion/sect2.htm,[10] that compares soil loss from different fabrics under a range of flows (with specified shear stress values) based on data collected in an outdoor flume. This source also provides comparative data on vegetation growth in different fabrics.

Fabric Type	Roll Dimension	Tensile Strength lb./in. (dry)	Permissible Velocity (ft./sec.)	Permissible Shear (lb./ft.^{2})	Cost (per yd^2)	Comments
Degradable, Nonwoven Coir	6-8 x 60-90 ft.	80 x 60	6	0.50	\$1 to \$2	Available with stronger, photodegradable netting.
Degradable, 700 g/m^2 Woven Coir	2,3 or 4 x 50m	120 x 80	14	1 to 2	\$2 to \$3	Specify seamless fabric in 3m, 4m widths.
Nondegradable, 2-D Synthetic Blanket	7 x 90 ft.	220 x 145	20	5.5	\$3 to \$5	
Nondegradable, 2-D Biaxial Grid	8 x 60 ft.	n/a		n/a	\$2 to \$3	Requires inner fabric to prevent loss of fine soil.
Nondegradable, 3-D Synthetic Matrix	8 x 90 ft.	260 x 180	25	10	\$7 to \$8	May limit planting of most woody

Nondegradable, 3-D Synthetic/Coir	6.5 x 55 ft.	n/a	n/a	2.25 to 8	$3 to $4	plant materials. May be the ideal synthetic fabric for streams.

Table 5. Fabric specifications and typical costs.

Other factors that guide fabric selection include cost, risk of failure and available fabric-roll dimensions. In some cases, a project stakeholder may prefer that no synthetic fabrics or staking materials be used on a particular site, in which case degradable fabrics or a more resilient, nonfabric-based treatment will be required. Actual field experience with a variety of fabrics will also dictate fabric preferences; some are easier to handle, while others are more difficult to plant or stake through. One important detail in fabric selection is to ensure the product has no seams; this is especially true for three- or four-meter-wide coir fabrics.

Fabric-Installation Guidelines

Although many manufacturers provide installation guidelines, these should be viewed with caution, as they may not be suitable for the intended use. To that end, some important concepts related to fabric installation and layout are discussed below.

Fabric Orientation

Fabric can be placed in a variety of configurations relative to the streambank, including placing roll lengths parallel, perpendicular or at an angle to the direction of the stream flow. General guidelines for fabric orientation exist, but a range of options should be considered during the design phase to ensure that the most easily constructed, cost-effective and resilient layout of fabric is used.

Staking

Numerous types of stakes are commonly used to secure fabrics. Metal stakes of any sort, including six- to eight-inch metal “U” staples and heftier rebar stakes (often with one end bent into an “L” or “U” shape to fasten fabric securely to the ground) seem incompatible with the concept of degradable, erosion-control fabrics, although they may be appropriate where synthetic fabrics are used. A variety of commercially developed, biodegradable pegs and stakes are availablebut generally do not provide adequate anchoring strength. Wooden stakes, often stocked by local lumberyards, may also be appropriate in some instances; however, they may not secure fabric tightly to the ground, and the fabric might easily lift off of straight stakes.

An excellent and more resilient alternative to all of these is 18- to 24-inch-long, wedge-shaped stakes made by cutting 2 x 4s diagonally. Narrow enough at the base to fit through woven coir fabric strands and wider at the top, these stakes pull fabric tightly as they are driven deeper, drastically reducing the chance of fabric lifting off the top. Once buried in a trench, the chance of stake pullout is slim, and the strength of the staking system will equal or exceed the strength of the fabric, provided they are spaced on three-foot or smaller intervals.

Deeply driven live willow stakes are sometimes used to make up a portion of the stakes needed to secure the fabric. Prior to root and shoot development, live stakes have the same disadvantages of wooden stakes in that, being straight rather than tapered, fabric may not be tightly secured to the ground and can easily lift off depending on how far they protrude from the ground. However, once established, the roots and shoots of the plant will secure the fabric better than wedge-shaped stakes. As growth is not guaranteed, live stakes are generally uniformly dispersed among other types of stakes and make up no more than one third of the required number of stakes used to secure the fabric.

Trenching

A fundamental component of erosion-control-fabric installation in difficult sites is to use trenching and buried staking to secure fabric edges. When using fabric up to three meters wide, sufficient tension can often be achieved without the need for surface stakes on the exposed fabric surface by staking all fabric edges in trenches. Trenching, especially on the upstream edges of fabric, also provides the benefit of burying the leading edge, which is a critical interface. Fabric edges parallel to flow may also be trenched in a variety of configurations for maximum erosion protection. A trench should be a minimum of six inches deep, then backfilled with common fill or topsoil, compacted and seeded.

Fabric Overlap

Another concept in fabric placement that must be carefully evaluated is the overlapping of fabric edges. It is often sufficient to simply “shingle” an upstream fabric edge over a downstream one and stake as needed. However, for extra reinforcement, it may be better to bury and stake the upstream edges of downstream fabric rolls in a key trench, then backfill the trench and place the downstream edge of the upstream fabric roll over the trench. A similar technique may be applied to edges parallel to stream flow.

Transitions

A potential weak point of any fabric-based streambank treatment is the transition between adjacent bank-treatment types, treated and untreated areas, or between fabric edges and existing infrastructure, such as bridges and culverts. If adequately designed and installed, transitions should not be a problem, but they will require that special consideration be paid to the orientation of fabric rolls and construction sequencing.

Construction Oversight

Even the best of designs will fail if not properly installed. Minor lapses in attention by installation workers or supervisors can lead to improper fabric tension, poor staking techniques, and the overlapping of fabric edges in the wrong direction. Any of these conditions can lead to increased fabric vulnerability during high flow events.

Table 6: Woody species recommended for revegetation of riparian corridors.[11]

FOOTNOTES

* Indicates plant propagates well from hardwood cuttings planted directly in the field.[2,3]

(1) Indicator Status = plant indicator status (UPL, FAC, etc., see below) From U.S. Department of the Interior, Fish and Wildlife Service.[12] A positive (+) sign, when used with indicators, means "slightly more frequently found in wetlands" and a negative (-) sign, when used with indicators, means "slightly less frequently found in wetlands." Species marked (†) indicate trees and shrubs tolerant of severe pruning (or grazing); these either stump sprout readily or form suckers from roots.
- UPL Obligate Upland: occurring almost exclusively in nonwetland environments.
- FACU Facultative Upland: occurring primarily in nonwetland environments, but occasionally found in wetlands.
- FAC Facultative: occurring with approximately equal frequencies in wetlands and nonwetlands.
- FACW Facultative Wetland: occurring primarily in wetland environments, but occasionally found in non-wetlands.
- OBL Obligate Wetland: occurring almost exclusively in wetland environments.
- NI No Indicator: there was insufficient data available to determine an indicator status.
- NOL Not on List: species does not occur in wetlands anywhere in the United States. Therefore, it is not included in the National List of Plant Species that Occur in Wetlands.[12]

(2) Maximum Height: the approximate height (feet) to which plants will grow under natural conditions with sufficient time. Mature height or the size at which plants begin to flower and produce seeds is substantially less in many species.

(3) Elevation Range: the elevations where the species commonly occurs. l=low, sea level to 2500 feet; m=med, 2500 to 4500 feet; h=high, above 4500 feet. All elevations are variable depending on microclimates.

(4) Plant Associations: planting suggestions for different soil. Information from the King County soil survey[13] and indicator status.[12] Nomenclature follows Flora of the Pacific Northwest[14] and National List of Plant Species that Occur in Wetlands.[12] Plant associations recommended for various soil moisture levels:

A. Very Droughty Soils: use UPL and FACU species. These conditions may be expected in porous or well-drained (sandy) soils or high on the bank, especially on south or west facing banks with little shade.

B. Droughty Soils: use mostly UPL and FACU species; FAC species may be used occasionally if site conditions are somewhat moist. These soils occur in areas similar to very droughty soil, but where moisture retention is better (e.g., less sandy soils, shade and north- or east-facing banks).

C. Moderate Soils: use FACU, FAC, and FACW species. Much of western Washington has these soils. They are loamy soils with some clay, on level areas to steep slopes. They may be shallow soils over hardpan or areas where seeps are common. Plant selection should consider microclimatic conditions including seeps, slope, aspect, etc. Steeper slopes, for example, will be drier than moderate soils because of water run off.

D. Wet Soils: use mostly FAC and FACW species; OBL species can be used in particularly wet areas as long as the soil is not compacted. They retain water rather than allowing it to run off after rain, and are moist to wet for most of all of the year. Because these areas have minimal slope and typically slow-moving streams, erosion is seldom a problem.

E. Very Wet Soils: use FACW and OBL species. These soils can be found along meandering rivers and streams with low banks. There is typically a high water table that allows the development of organic soils (peats and mucks). They are not well suited to large woody vegetation, as trees tend to blow over. Dense thickets of shrubs and small trees are common. Because these areas have minimal slope and typically slow-moving streams, erosion is seldom a problem.

(5) Light Requirement: sn = full sun, pt sh = part shade, sh = full shade.

(6) Rooting Character: "Fibrous" indicates that plant lacks a central root; root mass is composed of fibrous lateral roots. "Tap" indicates that plant has a stout, central main root. "Shallow," "moderate" and "deep" refer to relative rooting depth. Note that depth and character of roots are determined by soil conditions as well as species characteristics.

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The Pullman WA Plant Materials Center has the following technical notes available online (see http://www.wsu.edu/pmc_nrcs/technotes/tnotes.htm)
No. 21 Streambank Rehabilitation Using Willow Species and Hyrbrid Cottonwoods
No. 22 Comparison of Fifteen Cover Crops
No. 28. Native Plants Recommended for Wetland Riparian Plantings in the PNW
No. 29 Collection Willow Poplar and Redosier Dogwood Cuttings for Riparian Plantings
No. 30 Procedures for Implementing Field Plantings
No. 31 Riparian Moisture Zones – Planting Locations of Woody and Herbaceous Species
No. 35 Seeding Rate Statistics for Native and Introduced Species

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No. 39 Rooting Characteristics of Black Cottonwood and Pacific Willow
No. 43 Biology History and Supression of Reed Canarygrass
No. 44 Waterjet Stinger: A Tool to Plant Dormant Hardwood Unrooted Cuttings of Willows Cottonwoods and Dogwoods and Other Species